

Chapter 8

Notes on a Small Collection of Fishes from the Parc National de Marojejy, Northeastern Madagascar, with a Description of a New Species of the Endemic Genus *Bedotia* (Atherinomorpha: Bedotiidae)

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Abstract

A small collection of fishes from the Manantenina River in northeastern Madagascar is reported. Included in the collection are six native species, two Malagasy endemics, and one introduced species. One of the endemic taxa is a new species of the endemic rainbow fish genus *Bedotia*. The new species, *B. marojejy*, described herein, is readily distinguished from all congeners by a characteristic pigmentation pattern and low vertebral count.

Résumé

Une petite collection de poissons provenant de la Rivière Manantenina (nord-est de Madagascar) est rapportée. Six espèces natives, deux endémiques de Madagascar et une introduite sont incluses dans la collection. L'un des taxons endémiques est une espèce nouvelle qui appartient au genre *Bedotia*. La nouvelle espèce, *B. marojejy*, décrite ici se distingue de ses congénères par des pigmentations caractéristiques et un faible nombre de vertèbres.

Introduction

In a recent summary of the freshwater fishes of Madagascar, Stiassny and Raminosoa (1994) provide an annotated listing of the native fishes of the island. Although the continental waters of Madagascar are relatively depauperate in terms of overall species richness, there is a high-level of endemism (84%) in the freshwater ichthyofauna. Particularly striking is the fact that many of these endemic taxa are basal representatives of their respective clades (Stiassny, 1992; Stiassny & Raminosoa, 1994). Despite the pronounced threat to the island's freshwater ecosystems and the evo-

lutionary importance of many of these taxa, Madagascar's freshwater fish fauna remains relatively poorly documented and is often overlooked in conservation efforts. Benstead et al. (2000) have noted that if the criteria of the United States Endangered Species Act were applied to the fishes of the island, 10 species would be considered critically endangered and 12 would be considered threatened; insufficient data preclude accurate determination of the status of most of the remainder. There is clearly a strong impetus to continue with ongoing attempts to assess the taxonomic composition, range, and conservation status of the Malagasy ichthyofauna (Benstead et al., 2000; Reinthal & Stiassny, 1991, 1997; Stiassny & Raminosoa, 1994; Stiassny & Reinthal, 1992).

There have been few collections of fishes from the region of the Parc National (PN) de Marojejy,

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and with the exception of the description of a single taxon, *Rheocloides pellegrini* Nichols and LaMonte, 1931 (= *Rheocles pellegrini*; see Stiassny, 1990), collected during the Mission Zoologique Franco-Anglo-Américaine (Rand, 1936) from a locality "one day west of Andapa," no records of freshwater fishes from this area occur in the literature. In addition to the type of *R. pellegrini*, a number of other fishes collected during the Mission Zoologique Franco-Anglo-Américaine are deposited in the Ichthyology Department of the American Museum of Natural History (AMNH), and where appropriate these have been consulted as comparative materials. So too has a small collection of fishes from the Lokoho River, downstream of Belaoko, made by Patrick De Rham in October 1993 and deposited at the AMNH.

During the 1996 faunal survey of the PN de Marojejy a small collection of fishes from a locality at the banks of the Manantenina River at the southeastern boundary of the reserve (Fig. 8-1), about 28 km NE of the town of Andapa, was obtained. In view of the general paucity of material from this region and the pressing need for baseline taxonomic and distributional data for Malagasy fishes, a taxonomic report on the collection is presented here. Included among the material is a new species of rainbow fish of the endemic genus, *Bedotia* Regan, 1903, which is described herein.

Abbreviations

AMNH, American Museum of Natural History; BMNH, Natural History Museum, London; MNHN, Muséum National d'Histoire Naturelle, Paris; RMNH, Nationaal Natuurhistorisch Museum, Leiden; SL, standard length; TL, total length.

Taxonomic Review

1. Family Bedotiidae

The endemic Malagasy family Bedotiidae comprises the genera *Bedotia* Regan, 1903, and *Rheocles* Jordan and Hubbs 1919. Although *Rheocles* has been the subject of recent revision (Stiassny, 1990; Stiassny & Reinthal, 1992), the rainbow fishes of the genus *Bedotia* have received considerably less attention recently. Currently, the tax-

onomy of *Bedotia* is confused and greatly in need of modern revisional study (Arnoult, 1959; Kiemer, 1963; Catala, 1975). We have begun this process, and preliminary findings recognize five taxa (*B. madagascariensis* Regan 1903, *B. longianalis* Pellegrin 1914, and three undescribed species). The specimens of *Bedotia* from the Manantenina River are quite distinct from any of these other nominal forms and are readily diagnosable on the basis of a unique color pattern. Given the highly distinctive nature of the Manantenina specimens and the long-term nature of a comprehensive generic revision, the Manantenina species will be described herein and subsequently incorporated into a broader revisional study.

Bedotia marojejy, new species

(Figure 8-2)

HOLOTYPE—AMNH 224647, female, 46.6 mm SL. Banks of the Manantenina River (Lokoho River basin) at the SE boundary of the PN de Marojejy (approximate coordinates 14°28'S, 49°49'E), some 28 km NE of the town of Andapa. Collected by local fisherwoman using traditional dipnets. October–November 1996.

PARATYPES—AMNH 224648, two alcohol specimens, one male, 47.7 mm SL, one undetermined sex, 33.9 mm SL, one cleared and double-stained specimen, undetermined sex, 45.3 mm SL. Same data as holotype.

DIAGNOSIS—*Bedotia marojejy* is readily distinguished from all other nominal *Bedotia* by a distinctive color pattern characterized by a series of dark blotches arrayed along the lateral midline. In all other *Bedotia* species the lateral markings are dominated by a broad midlateral band of pigmentation, and similar blotching is never evident. *B. marojejy* is further distinguished from other *Bedotia* by a low total vertebral count of 34 (including the terminal, hypural-bearing half centrum), compared to 35–37 (very rarely 34) in the other species.

DESCRIPTION—Morphological measurements and meristic counts are given in Table 8-1. Measurement of standard length, head length, snout length, eye diameter, and caudal peduncle length and depth follows Kottelat (1990). Body depth is measured at the deepest part of the body, at the origin of the pelvic fins. The distance from the snout to the first or second dorsal fin is measured straight from the tip of the snout to a vertical through the base of the first fin ray in each fin

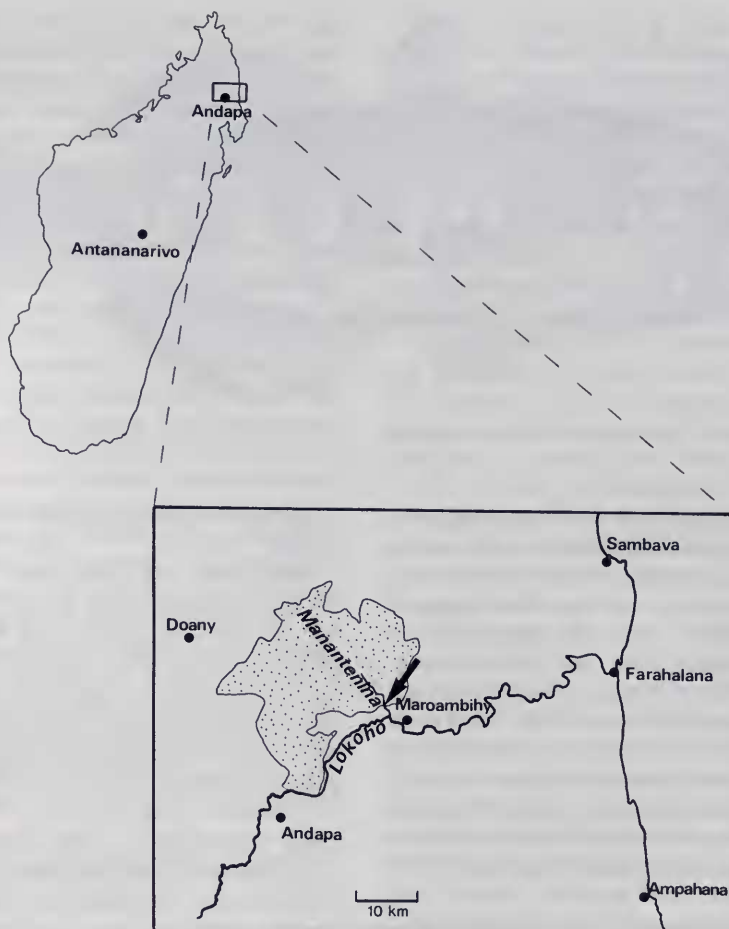


FIG. 8-1. Location of the PN de Marojejy (stippled area) in Madagascar. Arrow points to approximate locality in which fishes were collected.

respectively. Anal length is measured from the base of the first anal-fin ray to the base of the last fin ray. Lower jaw length is measured from the dentary symphysis to the posterior tip of the corner of the mouth. Currently the largest known specimen of *B. marojejy* is a 47.7 mm SL male.

Bedotia marojejy are robust, relatively short-bodied fishes somewhat deep-bodied anteriorly and with moderate belly curvature. Dorsum of head and nape broadly flatten to first dorsal fin. Origin of first dorsal is well behind vertical through pelvic-fin insertion, and origin of second dorsal is well behind vertical through origin of anal fin.

Snout is strongly indented behind prominent premaxillary pedicels. Lower jaw is prognathous and angled at about 30–35° to horizontal when mouth is closed. Premaxilla and maxilla reach

vertical through anterior margin of orbit. Premaxillae with deep lateral “bedotia notch” are characteristic of the genus (Stiassny, 1990).

Teeth—Anteriorly both upper and lower jaws bear two to three rows of numerous small, strongly recurved unicuspid teeth. The inner and outer rows of teeth are poorly differentiated. The lower jaw and the premaxilla posterior to the bedotia notch each have a single row of teeth. A single row of teeth is present along the anteroventral face of vomer, and a tiny patch of endopterygoid teeth is also present. No palatine or ectopterygoid teeth are present, at least in individuals of sizes available for examination.

Gill Rakers—Two or three stout hypobranchial rakers and eight or nine elongate ceratobranchial rakers are present on the lower limb of the first branchial arch. All rakers are strongly denticulate.

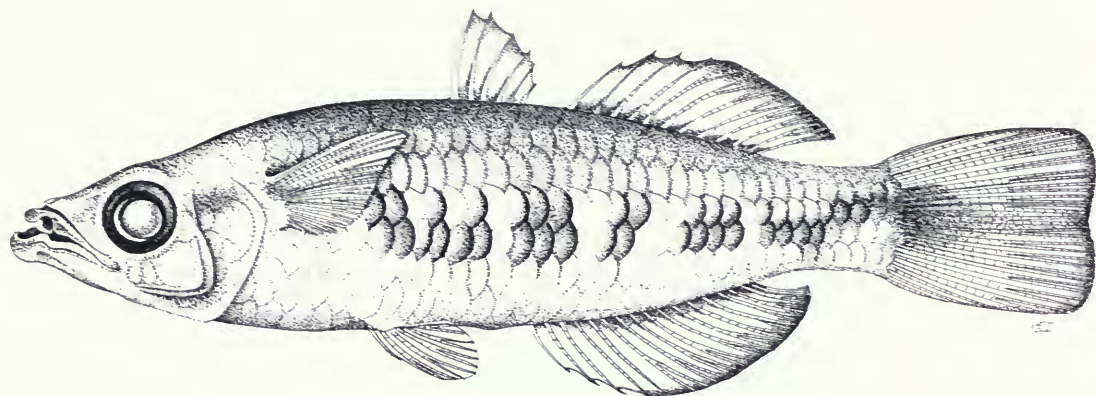


FIG. 8-2. Holotype of *Bedotia marojejy* sp. nov., AMNH 224647, female, 46.6 mm SL.

Scales—Body is covered with large, regularly imbricate, cycloid scales. Predorsal scales number 16 or 17 along the dorsal midline. Thirty-two or 33 scales occur along the midlateral axis from just behind the operculum, above the pectoral fin, to the end of the hypural plate. Ten scales in transverse series are located between the anal fin and the second dorsal fin (including a very small scale adjacent to each fin). One or two scales separate the first and second dorsal fins. Twelve or 13 scales in transverse series are located entirely around the caudal peduncle (circumpeduncular series). Dorsal, anal, and caudal scale sheaths and

axillary pelvic scales are absent. The body is fully scaled.

Fins—First dorsal fin bears six weak spines. Second dorsal fin bears 12 or 13 rays, with the first 3 or 4 unbranched. Anal fin bears 17 rays, usually with the first 5 unbranched. Pectoral fin bears 14 rays that are high set and relatively short, the longest upper rays extending only a little beyond the vertical from the pelvic-fin insertion. The pelvic fin has one weak spine and five strongly bifurcate, branched rays. The caudal fin is weakly emarginate.

Vertebrae—Total vertebral count (taken from

TABLE 8-1. *Bedotia marojejy*, new species.

Character Evaluated	Holotype	Paratypes (N)	Min.*	Max.	Mean
Standard length	46.6	3	33.9	47.7	43.4
Head length (% SL)	30.6	3	27.0	30.0	29.1
Snout length (% HL)	32.9	3	30.7	31.3	31.7
Eye diameter (% HL)	27.3	3	26.9	30.7	28.3
Body depth (% SL)	23.3	3	23.7	24.0	23.7
Caudal peduncle length (% HL)	54.5	3	54.6	57.5	55.5
Caudal peduncle depth (% HL)	33.6	3	34.6	36.0	34.7
Snout—first dorsal origin (% SL)	54.4	3	52.1	52.8	52.9
Snout—second dorsal origin (% SL)	65.3	3	63.9	65.4	65.0
Anal length (% SL)	28.3	3	27.0	29.7	28.1
Lower jaw length (% HL)	51.0	3	48.7	53.0	50.9

Character Evaluated	Holotype	Paratypes (N)	Range	Distribution
Longitudinal scales	33	3	32–33	32 (1) 33 (3)
Gill rakers (lower arch)	11	3		11 (4)
Anal rays	17	3		17 (4)
Second dorsal rays	12	3	12–13	12 (3) 13 (1)
Vertebrae—total	34	3		34 (4)
(Precaudal + caudal + terminal half centrum)	(17 + 16 + 1)			(17 + 16 + 1)(4)

*Min. and max. are the ranges only for the paratypical series, whereas the mean represents the entire sample.

radiographs and directly from the cleared and double-stained specimen), 34: 17 precaudal vertebrae (haemal arch not fused), 16 caudal vertebrae (haemal arch fused), and terminal, hypural-bearing half centrum. As noted in the diagnosis, a total vertebral count of 34 is rarely encountered in other *Bedotia* species. However, the sample size for *B. marojejy* is small compared with the number of specimens available for the five nominal congeneric species, and intraspecific variation within *B. marojejy* may be underestimated.

Preserved Coloration—Ground color in both male and female specimens is a pale creamy yellow. Dorsum of snout, nape, and body is darkly pigmented. A black bar passes from the symphysis of the lower jaw through the eye to the posterodorsal border of the opercle. A dark crescentic patch occurs at the pectoral-fin base. A series of 6 to 8 darkly pigmented blotches is arrayed along the lateral midline. The ventrum of head, chest, and body is pale creamy yellow. A broad wedge of pigment occurring at the caudal-fin base extends as a narrow median stripe to the caudal margin. The caudal margin and ventral and dorsal edges are darkly pigmented. The bases of the second dorsal and anal fins are darkly pigmented, and both fins have distal margins, also darkly pigmented. No data on live coloration are currently available.

Viscera and Diet—Gut extremely short, intestinal length only about one-third body length. In all four specimens the intestines are almost empty, containing nothing but a few partially disarticulated insects. In all individuals the remains of both aquatic (larvae) and terrestrial insects were found, suggesting that this species is probably essentially insectivorous, opportunistically feeding on both autochthonous and allochthonous sources.

DISTRIBUTION—Currently the species is known only from the type locality in the Manantenina River. In view of the paucity of collections from this region, however, it is probable that additional populations of *B. marojejy* are present in similar habitats throughout the surrounding area.

ETYMOLOGY—The specific epithet was made in reference to the locality in which the type series was collected.

2. Family Anguillidae

Anguilla marmorata Quoy and Gaimard, 1824
(See Castle (1984) for synonymies)

One specimen of *Anguilla marmorata* was collected at the Manantenina River site (AMNH

226649, 570 mm TL). It accords well with descriptions of the species by Bauchot and Bianchi (1984) and Skelton (1993) in having the dorsal-fin origin nearer to the gill slit than to the anus, the maxillary toothbands with distinctive longitudinal grooves, and in being heavily mottled brownish black. These features readily distinguish *A. marmorata* from the three other anguillids currently recognized in Malagasy freshwaters: *A. mossambica* (Peters, 1852), *A. bicolor* McClelland, 1844, and *A. bengalensis labiata* (Peters, 1852).

Anguilla marmorata, commonly called the giant mottled eel, attains lengths of up to 185 cm TL (Skelton, 1993). It is widespread in fresh and brackish waters from sea level up to altitudes of 300–900 m throughout Madagascar (Kiener, 1963). Outside of Madagascar *A. marmorata* is widespread from Western Cape Province to Kenya in Africa (Skelton, 1993), the Comoros (Teugels et al., 1985), and east to Polynesia and the Ryukus, Japan.

COMPARATIVE MATERIAL—*Anguilla marmorata*: AMNH 88113, 460 mm TL, Toamasina (Tamatave), main marketplace in town center, Madagascar, 15-VII-1988, M. L. J. Stiassny, P. N. Reinthal; AMNH 88125, 400 mm TL, Toamasina (Tamatave), main marketplace in town center, Madagascar, 15-VII-1988, M. L. J. Stiassny, P. N. Reinthal; AMNH 58991, 62.4 mm, 170 mm, 175 mm TL, creek crossing N coast road ca. 4.5 km N of Bogia, Madang drainage, New Guinea, 19-X-1987, L. R. Parenti, G. R. Allen, D. Coates.

Anguilla mossambica (Peters, 1852)
(See Castle (1984) for synonymies)

One specimen of *Anguilla mossambica* was collected at the Manantenina River site (AMNH 226650, 320 mm TL). It too accords well with descriptions of the species by Bauchot and Bianchi (1984) and Skelton (1993). Like *A. marmorata*, *A. mossambica* has the dorsal-fin origin nearer to the gill slit than to the anus, and this readily distinguishes it from the other two Malagasy anguillids. *A. mossambica* lacks the mottled coloration, and its maxillary toothbands lack the longitudinal grooves characteristic of *A. marmorata*.

Anguilla mossambica, commonly called the African longfin eel, attains lengths of up to 120 cm TL (Skelton, 1993). It is the most widespread of all Malagasy freshwater eels and is found from sea level up to altitudes of over 900 m throughout

the island (Kiener, 1963). Outside of Madagascar *A. mossambica* is commonly encountered on the African mainland in east coast rivers from Kenya south to Cape Agulhas, Republic of South Africa, and it occurs on other western Indian Ocean islands (Skelton, 1993).

COMPARATIVE MATERIAL—*Anguilla mossambica*: AMNH 88114, 295 mm TL, Toamasina (Tamatave), main marketplace in town center, Madagascar, 15-VII-1988, M. L. J. Stiassny, P. N. Reinthal; AMNH 88010, 490 mm TL, town of Ranomafana, Namorona River in shallow pools cut off from mainstream by rocky outcrops, Madagascar, 26-VI-1988, M. L. J. Stiassny, P. N. Reinthal; AMNH 11686, 399 mm TL, Madagascar, 1931, Archibold Expedition (= Mission Zoologique Franco-Anglo-Américaine), A. L. Rand, W. H. du Mont.

3. Family Mugilidae

Agonostomus telfairii Bennett, 1831

(See Thomson (1986) for synonymies)

A single specimen of *Agonostomus telfairii* was collected (AMNH 226651, 191 mm SL). Thomson (1997) recognized two Indian Ocean species of *Agonostomus* in his revision of the Mugilidae, namely *A. catalai* Pellegrin, 1932, with a thick upper lip, and *A. telfairii*, with a thinner lip. In the holotype of *A. catalai*, collected from the Haute Mananano, Sahasinaka District, Madagascar, the mid-height of the upper lip is 21% of the head length; in the holotype of *A. telfairii*, collected from Mauritius, the upper lip thickness is 10% of the head length. The specimen from the Manantenina River has an upper lip thickness of 17% head length. Examinations of comparative material indicate a complete range of lip thickness; for example, a collection from the Nosivolo River (Mangoro drainage), Madagascar, includes 11 specimens of *Agonostomus* (AMNH 97100) with lip thickness graded from 11% to 18% of head length. Ingham (1952) and Thomson (1997) stated that the thick-lipped species, *A. catalai*, could be distinguished by having only a single row of teeth in the lower jaw; however, collections examined in this study include specimens of *Agonostomus* with thick lips and up to three irregularly arranged rows of teeth in the lower jaw. Other distinguishing features for *A. catalai* given by Thomson (1997) include the relative position on the head of the upper part of the preorbital and

posterior tip of the upper jaw, relative position of the pelvic fin, and number of gill rakers. However, it is not possible to satisfactorily distinguish between the two species using these features.

Agonostomus telfairii (here including *A. catalai*) is known from rivers of Madagascar, Anjouan (Comoros), and the Mascarene islands of Réunion and Mauritius (Thomson, 1980). According to Catala (1975), in Madagascar *A. catalai* (= *A. telfairii*) is restricted to the upper reaches of fast-flowing, rocky streams where it feeds exclusively on algae. Kiener (1963) suggested that, in Madagascar, *A. telfairii* would be unable to ascend the rapids and waterfalls of the fast-flowing hill streams.

Besides *A. telfairii* (including *A. catalai*), Ingham (1952) and Thomson (1997) recognized only one other species of *Agonostomus*, *A. monticola*, which is insectivorous and inhabits the upper reaches of torrential, rocky rivers in Central and South America (Cruz, 1987; Phillip, 1993). However, *A. monticola* is thought to migrate during the rainy season down to coastal waters, where it spawns before immediately returning upstream. After a short period at sea, the prejuveniles return to the rivers and migrate upstream (Cruz, 1987; Ditty & Shaw, 1996). Hill streams and rivers comprising isolated pools separated by small waterfalls may not present a barrier to upstream migration because *A. monticola* is an accomplished leaper (K. Lazara, pers. comm.). *A. telfairii* might show a similar, catadromous ecology to *A. monticola*. *A. telfairii* can reach ca. 36 cm SL; it is taken in subsistence fisheries but not commercially (Thomson, 1980).

The global distribution of *Agonostomus* is remarkably disjunct; *A. monticola* is restricted to rivers of Central America, northern South America, and the Galapagos Islands (Harrison, 1995; Thomson, 1978, 1997), and *A. telfairii* is restricted to rivers of the aforementioned islands of the western Indian Ocean. There is not sufficient information to provide any well-supported explanation for this distribution of *Agonostomus*. However, two possible scenarios would benefit from further analysis. One explanation is that this is the relict of a former Tethyan distribution, with extension into the eastern Pacific during the Oligocene and Miocene. This distribution would have been disrupted by two vicariance processes: Miocene closure of the Mediterranean, with the associated Messinian salinity crisis of that region, and development of the current Panamanian isthmus during the Pliocene. A former Tethyan con-

nection between Indo-Pacific and Atlantic relatives has been discussed for various taxa; for example, cods (Howes, 1991), gobies (Harrison, 1993; McKay & Miller, 1997), and anguillid eels (Tagliavini et al., 1996; Tsukamoto & Aoyama, 1998). Anguillid eels, like species of *Agonostomus*, have a catadromous lifestyle (McDowall, 1997). Vicariance biogeography of the Caribbean and eastern Pacific regions has been discussed by various authors (e.g., Coates & Obando, 1996; Iturralde-Vincent & MacPhee, 1999; Rosen, 1975; White, 1986).

An alternative hypothesis is that the current distribution of *Agonostomus* is a relict of a prolonged Gondwanan link between Indo-Madagascar and South America, via Antarctica, that may have lasted until ca. 80 million years ago (Sampson et al., 1998). This scenario requires *Agonostomus* to be at least twice as old as the oldest known fossil mugilid, dated to 30–40 MYBP (Patterson, 1993). This may be possible, considering information for other smegmamorphs (*sensu* Johnson & Patterson, 1993). White (1986) discusses Cretaceous ancestral antherinids, although the earliest fossil material is from the early Eocene, and the minimum age of cyprinodontiforms is estimated to be late Triassic, although the oldest described fossil cyprinodontiform is from the Oligocene (Parenti, 1981; Patterson, 1993). Contemporary distribution of *Agonostomus* through South America would, according to this scenario, be related to the very complex processes of Andean orogeny, associated changes in South American riverine drainages, and periodic marine transgressions, through the late Cretaceous and Tertiary (for discussion see Harrington, 1962; Lundberg, 1997; Lundberg et al., 1998; Schaefer, 1997; Webb, 1995; Weitzman & Weitzman, 1982).

COMPARATIVE MATERIAL—*Agonostomus telfairii*: BMNH 1861.8.14.9, holotype, 108.5 mm SL, Mauritius, Gerrard; AMNH 215499, 2 specimens, 79.3 mm and 84.7 mm SL, Lokoho River, Andapa region, downstream Belaoko, northeast Madagascar, P. De Rham, 21-X-1993. *Agonostomus telfairii* var. *catalai*: MNHN 1932-162, holotype, 129.8 mm SL, Haute Mananano, Madagascar, Catala; BMNH 1865.9.21.4-5, 2 specimens, 175 and 195 mm SL, Johanna (?Anjouan); presented by Col. Playfair; BMNH (no register no.), 126.5 mm SL, Madagascar, Dr. S. E. Gray; AMNH 97100, 11 specimens, 136.5–227 mm SL, Tamatave Province, Nosivolo River, below Zule's Village, deep pools, Madagascar, M. L. J. Stiassny, P. N. Reinthal, and G. J. P. Naylor, 23-IX-1990; AMNH

97112, 132 mm SL, Toamasina (Tamatave) Province, Nosivolo River, 10 km upstream from Marolambo, Madagascar, M. L. J. Stiassny, P. N. Reinthal, and G. J. P. Naylor, 23-IX-1990. *Nestis cyprinoides*: MNHN 5553, syntype, 207.5 mm SL, Île de France (Île Maurice), Désjardins; MNHN A.963, 2 syntypes, 163 mm and 146.2 mm SL, Île de France (Île Maurice), Dussumier; MNHN A.4318, 2 syntypes, 67.8 mm and 65.8 mm SL, Île Bourbon (La Réunion), Leschenault. *Nestis dobuloides*: MNHN A.4650, holotype, 360 mm SL, Île de France (Île Maurice), Lamarre Pi-quot.

4. Family Cichlidae

Paratilapia polleni Bleeker, 1868

(See Maréchal and Gosse (1991) for synonymies)

Three specimens of the endemic cichlid genus, *Paratilapia*, were collected at the Manantenina River site (AMNH 226652; 54.7 mm SL, 50.6 mm SL, 33.0 mm SL). Although most contemporary authors follow Pellegrin's (1904) synonymy of *Paracara typus* Bleeker, 1878, and *Paratilapia bleekeri* Sauvage, 1891, with *P. polleni* Bleeker, 1868, several field biologists have noted the existence of distinct local phenotypes (Loiselle, 1995). In a preliminary taxonomic note on the genus, Loiselle and Stiassny (1993) resurrected Sauvage's *P. bleekeri*, noting, among other features, the large size of the spots and spangling of this species when compared with the small spots of *P. polleni*. However, Loiselle and Stiassny (1993) accepted the synonym *Paracara typus* with *Paratilapia polleni*, mainly because of a paucity of comparative material and the extremely poor state of the single type specimen of *P. typus*. In the absence of a thorough revision there remains considerable confusion regarding the species-level taxonomy of *Paratilapia*. The problem of a definitive identification of the Manantenina material is compounded by the fact that the specimens lack the diagnostic coloration and patterning of adult fish. However, based on a morphometric appraisal, the Manantenina specimens appear to approximate the more gracile, longer-jawed *P. polleni* phenotype than the deeper-bodied, shorter-jawed *P. bleekeri*. Interestingly, although the Manantenina specimens exhibit a typical juvenile *Paratilapia* patterning of 8–9 narrow, closely spaced vertical bars and a large ocellated tilapia-spot in the soft dorsal fin (Stiassny & Ger-

stner, 1992), the largest individual is a male with advanced testicular development. According to Kiener (1963), *P. polleni* are sexually mature at about 12 cm on the Central High Plateau, compared to 8 cm in the nutrient-poor acid waters of the coastal plain where growth rates are retarded. The Manantenina populations apparently are attaining sexual maturity at a notably smaller size.

Prior to the extensive deforestation of the island and the introduction of predatory exotic species, *Paratilapia polleni* was the most widespread of all Malagasy endemic cichlids, being recorded from most regions of the island (Kiener, 1963; Kiener & Maugé, 1966). However, because the species cannot survive temperatures lower than 12–15°C, it has always been absent from areas much above 1500 m (Kiener, 1963). *P. polleni* has been eradicated from much of its original range by habitat alteration and introduced exotic species. Today, although both *P. polleni* and *P. bleekeri* are still widely distributed in eastern coastal regions, they are nowhere abundant. *P. polleni* is recorded as attaining sizes of 30 cm, although individuals of that size are rarely encountered today.

COMPARATIVE MATERIAL—*Paratilapia polleni*: RMNH 4.483, syntype, 119.3 mm SL, “Ambassuana” Madagascar septentrionalis in fluviis (Nosy-bé), 1864; RMNH 6.690, syntypes, 104.4 mm SL, 60.1 mm SL, “Ambassuana” Madagascar septentrionalis in fluviis (Nosy-bé), 1864; RMNH 3.994, syntype, 117.5 mm SL, “Ambassuana” Madagascar septentrionalis in fluviis (Nosy-bé), 1864; AMNH 18842, Region d’Ankarana, Waterlot; AMNH 11689, Madagascar, Mission Zoologique Franco-Anglo-Américaine (= Archibold Expedition), 28-IX-1931; AMNH 97002, Bay Lake behind first dune, ca. 100 m from sea, east of road by Salehy Village, 1 km S of turnoff from Marolambo-Mananjary Road, Toamasina (Tamatave) Province, Madagascar, 16-IX-1990, M. L. J. Stiassny, P. N. Reinthal, G. J. P. Naylor; AMNH 97030, Mouth of Mangoro River, opposite camp by Salehy Village, Toamasina (Tamatave) Province, Madagascar, 17-IX-1990, M. L. J. Stiassny, P. N. Reinthal, G. J. P. Naylor. *Paracara typus*: RMNH holotype, Madagascar orientalis in fluviis (riviére de Mananara, à l’entrée de la baie d’Antongil), specimen disarticulated. *Paratilapia bleekeri*: MNHN A.4195, syntypes, 90.3 mm SL, 88.0 mm SL, 84.4 mm SL, marais et rizières de l’Imerina, près d’Antananarivo.

Oreochromis mossambicus (Peters, 1852)

(See Trewavas and Teugels (1991) for synonymies)

Four juvenile specimens of the introduced African cichlid *Oreochromis mossambicus* were collected at the Manantenina River site (AMNH 226653; 63.6 mm SL, 56.2 mm SL, 52.6 mm SL, 34.1 mm SL). They conform to the descriptions of the species (e.g., Trewavas, 1983; Skelton, 1993) and exhibit numerous vertical bars and a characteristic series of 2–5 midlateral blotches and some blotches of a more dorsal series. Apparently *O. mossambicus* was introduced into Madagascar from Mozambique in 1956 by the Forestry Service for use in “rizipisciculture” (the culture of fishes in flooded rice fields; Kiener, 1963). The species is now widespread throughout the island.

5. Family Eleotridae

Eleotris fusca (Schneider, 1801)

(See Maugé (1986b) for synonymies)

Four specimens of *Eleotris* were collected at the Manantenina River site (AMNH 226654; 2 males, 121.7 mm and 94 mm SL, and 2 females, 119.3 mm and 89 mm SL). They generally accord with Akihito’s (1967) and Hoese’s (1986) descriptions of *E. fusca*, having 8 or more gill rakers on the first epibranchial, 61–66 scales in a longitudinal series, infraorbital transverse rows 2, 4, and 6 penetrating below longitudinal row d, and 9 transverse infraorbital rows anterior to row b (the last two characters are ambiguous in the smallest specimen). These features distinguish *E. fusca* from the very similar *E. melanosoma* Bleeker. However, examination of comparative material indicates that infraorbital papillae patterns are variable. For example, specimens with high scale counts (indicative of *E. fusca*) have an *E. melanosoma* type papillae patterning, or intermediate papillae patterns. It will not be possible to resolve the taxonomy of Malagasy species of *Eleotris* more precisely until a detailed review of the 13 nominal Indo-West Pacific species (Miller, 1998) has been conducted.

Eleotris fusca attains 26 cm (Hoese, 1986). It is currently reported as a widespread, epibenthic species, found in fresh, brackish, and littoral waters throughout much of Madagascar and from the east African coast eastward to Polynesia (Catala,

1982; Maugé, 1986b). However, this distribution requires confirmation through a taxonomic review of the species.

COMPARATIVE MATERIAL—*Eleotris fusca*: AMNH 215521, male, 121 mm SL, Nosy-bé, Djabala River, near Ampombilava village, Madagascar, P. Loiselle, 18-IX-1990. *Eleotris melanosoma*: AMNH 96904, male, 53.9 mm SL, Toamasina (Tamatave Province), main market place in town center, caught nearby, Madagascar, local fishermen, M. L. J. Stiassny, P. N. Reinthal, 15-XII-1988. *Eleotris* cf. *melanosoma*: AMNH 051509, male, 102.8 mm SL, 1 day W of Andapa, northern Madagascar, Mission Zoologique Franco-Anglo-Américaine (= Archibold Expedition), A. L. Rand, W. H. du Mont, 2-X-1931; AMNH 097039, 7 specimens, 17.9–41.3 mm SL; Toamasina (Tamatave) Province, small affluent tributary, River Mangoro, ca. 1 km upstream of Mangoro ferry crossing, Madagascar, M. L. J. Stiassny, P. N. Reinthal and G. J. P. Naylor, 17-IX-1990; AMNH 97048, 1 male, 154 mm SL, 3 females, 64.6–102.2 mm SL, Toamasina (Tamatave) Province, small stream ca. 20 km from Mangoro ferry crossing on road to Marolambo, through banana plantation, Madagascar, M. L. J. Stiassny, P. N. Reinthal, and G. J. P. Naylor, 18-IX-1990.

6. Family Gobiidae

Awaous aeneofuscus (Peters, 1852)
(See Maugé (1986a) for synonymies)

Two specimens of *Awaous* were collected at the Manantenina River site (AMNH 226655; 1 female, 178 mm SL, and 1 male, 121.8 mm SL). Both specimens conform to descriptions of *A. aeneofuscus* (for example, Catala, 1982; e.g., with 26–36 small predorsal scales extending anteriorly to a vertical through the preopercular canal, scales absent on the opercle and preopercle, 55–60 scales in longitudinal series, and the mouth not extending beyond the anterior of the eye. There are two dark bands running anteroventrally from the eye toward the mouth, and the body has a series of dark brown patches just dorsal to the midline (see Teugels et al., 1985, fig. 7). The pigmentation features are more distinct in the smaller male specimen than in the large female. For a general comparison, see photographs in Schmidt et al. (1996, p. 34); the female appears similar to the large specimen shown in photograph 2, and

the smaller male is slightly darker than the specimen in photograph 10.

Awaous aeneofuscus inhabits fresh and brackish waters of South Africa, Mozambique, Madagascar, and the Comoros (Teugels et al., 1985; Maugé, 1986a). Kiener (1963) reports that the species may be found at altitudes up to 950 m. It may attain 35 cm SL (Catala, 1982), although larger specimens tend to be found not as far up-river (Kiener, 1963).

COMPARATIVE MATERIAL—*Awaous aeneofuscus*: AMNH 215496, 2 males, 85.8 mm and 91.2 mm SL, Lokoho River, Andapa region, downstream of Belaoko, northeast Madagascar, P. De Rham, 2-X-1993; AMNH 88093, 1 male (from collection of 14 specimens), 134 mm SL, Pangalanes north of Mangoro River, Mahanoro town behind Hotel de la Pangalane, Madagascar, M. L. J. Stiassny, P. N. Reinthal, 9-VII-1988; AMNH 097055, 3 females, 76.4–148 mm SL, Toamasina (Tamatave) Province, Savalany River (small stream) by Ambodisovoka village, bridge over road to Marolambo, Madagascar, M. L. J. Stiassny, P. N. Reinthal, and G. J. P. Naylor, 18-IX-1990.

Subfamily Sicydiinae

Catala (1982) listed five sicydiine species from Madagascar or neighboring islands, incorrectly placing them all within the genus *Sicydium* Valenciennes. These were: *S. acutipinnis* (Guichenot), *S. franouxi* Pellegrin, *S. fasciatum* Day, *S. laticeps* Valenciennes, and *S. lagocephalum* (Pallas). Maugé (1986a) reassigned the species *acutipinnis* Guichenot to its original genus, *Cotylopus* Guichenot, 1863, and noted that reports of this species from Madagascar are doubtful. Watson's (1995) review of the genus and species concurred, and he listed *acutipinnis* as known only from Réunion. Additionally, Catala's (1982) description of *S. acutipinnis* is inaccurate, citing a very high scale count: 75 in longitudinal series, compared to 46–63 cited by Watson (1995). The remaining Malagasy species are all assigned to the genus *Sicyopterus* Gill, 1861 (Maugé, 1986a). *S. laticeps* has been synonymized with *S. lagocephalum* (Smith, 1959; Maugé, 1986a).

Sicyopterus fasciatus and *S. franouxi* are very similar, and Maugé (1986a) listed *Sicydium franouxi* (= *Sicyopterus franouxi*) as a possible synonym of *Sicyopterus fasciatus*. Pellegrin (1935) and Catala (1982) refer to the absence of scales on the median part of the nape of the neck and

median part of the abdomen in *S. franouxi* as a character differentiating it from *S. fasciatus*. Examination of comparative material indicates that differences in scalation of the nape are difficult to detect and perhaps subjective. However, comparison of similar-sized specimens of *S. franouxi* and *S. fasciatus* (114 mm SL, AMNH 097149; and 115 mm SL, AMNH 215495, respectively) indicates that the abdomen of *S. fasciatus* is entirely scaled, whereas that of *S. franouxi* is less well-scaled ventromedially. Smaller specimens of *S. franouxi* also usually have the ventromedial part of the abdomen less well-scaled, or naked, compared to the ventrolateral parts of the abdomen, although this is slightly variable. Pellegrin (1935) referred to the coloration of *S. franouxi* as being diagnostic, and this seems to be the most reliable feature for differentiating it from *S. fasciatus*. In most specimens of *S. franouxi* the anterior of the snout, just above the upper lip, is dark brown and continues as a dark brown band that runs beneath the eye and over the mid part of the preopercle towards its dorsoposterior margin. A prominent, longitudinal dark brown band extends along the midline of the body from the pectoral axilla to the anterior half of the caudal fin. The rest of the body is usually a lighter brown. This background pigmentation is darker in some specimens, however, such that the longitudinal band, although still visible, is less distinct. Some of the lighter specimens show traces of four or five dark brown, transverse bars on the body, and Pellegrin's (1935) original description refers to these. These transverse bands

may be more prominent in fresh specimens, as suggested by a photograph, labeled as "*Sicyopterus pranouxi*" [sic] in Schmidt et al. (1996, p. 34, photograph 5). The base of the pectoral fin is dark brown dorsally, at the same level as the longitudinal band on the body. The pectoral fin rays are darkish brown near their bases but paler distally, producing a crescent-shaped band of dark pigmentation over the fin. In comparative material of *Sicyopterus fasciatus* the snout and sides of the head are dark brown or dark gray, but this species lacks the distinctive longitudinal band of dark brown pigmentation that runs the length of the body in *S. franouxi*. Day's (1876, p. 299) description and figure (pl. 54) of *S. fasciatus* give no indication of a dark brown longitudinal bar. The body coloration in *S. fasciatus* appears to be more of a gray-brown than the light brown seen in *S. franouxi*. The available comparative material of *S. fasciatus* shows only vague traces of transverse bands of dark brown pigment on the body, but Day's description and figure indicate that the bands are quite distinct. The pectoral fins of *S. fasciatus* have a more uniform dark gray-brown pigmentation than those of *S. franouxi*.

The possibility of conspecificity between *S. fasciatus* and *S. franouxi* should not be discounted. However, until a more detailed review of western Indian Ocean sicydiines has been completed it seems reasonable to distinguish between the *S. fasciatus* and *S. franouxi* according to the squamation and pigmentation features described above. A provisional key for Malagasy species of *Sicyopterus* follows:

- 1a. Scales on nape and ventral part of abdomen much smaller than those on flanks; 58–63 scales in longitudinal series (excluding scales on caudal fin) 2
- 1b. Scales on nape and ventral part of abdomen more or less equal in size to those on flanks; usually 52 or fewer scales in longitudinal series (excluding scales on caudal fin) *Sicyopterus lagocephalus*
- 2a. Distinct, longitudinal, dark brown bar along midline of body; body otherwise lightish brown; pectoral fin darkish brown near base and on mid-part of fin but paler distally, producing a crescent-shaped band of dark pigmentation over the fin; ventromedial part of abdomen usually lacking scales *Sicyopterus franouxi*
- 2b. No dark brown longitudinal bar along midline of body; body grayish brown; pectoral fin uniform dark gray-brown; ventromedial part of abdomen entirely scaled *Sicyopterus fasciatus*

***Sicyopterus lagocephalus* (Pallas, 1774)**
(See Maugé (1986a) for synonymies)

One sicydiine collected at the Manantenina River site (AMNH 226656, 1 female, 109.0 mm

SL) is identified as *Sicyopterus lagocephalus* according to the above key. This species is darkish gray-brown, with traces of five or six transverse, darker brown, bands on the body and a longitudinal, dark brown band running along the midline.

The pectoral fins have a uniform dark brown pigmentation. The collected specimen (AMNH 226656) is slightly darker brown than other comparative material. Catala's (1982) scale count for *S. lagocephalus* (57–65) is high according to the available comparative material.

Sicyopterus lagocephalus inhabits swift-flowing streams of Madagascar, Réunion, Mauritius, and the Comoros (Maugé, 1986a; Teugels et al., 1985; Watson, 1995). *S. lagocephalus* attains ca. 120 mm total length and is presumably amphidromous like other sicydiine gobies; the adults reproduce in freshwater, and the larvae are carried down to the sea, where they remain for some time before returning to freshwater to mature and reproduce (Harrison, 1993; McDowall, 1997; Watson, 1998). The ascent of enormous numbers of postlarval *S. lagocephalus* up rivers of Réunion and Madagascar has been reported by Valenciennes in Cuvier and Valenciennes (1837) and Kiener (1963). The migratory return of postlarvae to freshwater more or less coincides with each new moon; the more significant migrations in Madagascar occur between April and September (Kiener, 1963). The postlarvae are fished by local people and eaten fresh or dried.

COMPARATIVE MATERIAL—*Sicyopterus lagocephalus*: AMNH 215498, 3 males, 76.4–104.0 mm SL, Lokoho River, Andapa region, downstream of Belaoko, northeast Madagascar, P. De Rham, 21-X-1993. *S. fasciatus*: AMNH 215495, 1 male, 134 mm SL, and 1 female, 115.2 mm SL, Lokoho River, Andapa region, downstream of Belaoko, NE Madagascar, P. De Rham, 21-X-1993. *S. franouxi*: AMNH 097149, 4 females?, 77.1–113.6 mm SL, Toamasina (Tamatave) Province, Nosivolo River below Ambatomasina village, ca. 16 km E-NE of Marolambo, in large pool, Madagascar, M. L. J. Stiassny, P. N. Reinthal, and G. J. P. Naylor, 21-IX-1990; AMNH 097071, 2 females, 52.6 mm and 83.6 mm SL, and one specimen of undetermined sex, 54.6 mm SL, Toamasina (Tamatave) Province, Sahala River, near Andranavolo, Madagascar, M. L. J. Stiassny, P. N. Reinthal, and G. J. P. Naylor, 19-IX-1990; AMNH 097080, 4 females, 73.8–98.5 mm SL, 1 male, 63.7 mm SL, and 2 specimens of undetermined sex, 67.8 mm and 95.5 mm SL, Toamasina (Tamatave) Province, Nosivolo River, below Ampasimanionia village, 26 km E-NE of Marolambo, large side pool below rapids, Madagascar, M. L. J. Stiassny, P. N. Reinthal and G. J. P. Naylor, 20-IX-1990; AMNH 097068, 1 specimen of undetermined sex, 38.6 mm SL, Toamasina (Tamatave)

Province, stream by Ambinanindrano, Madagascar, M. L. J. Stiassny, P. N. Reinthal, and G. J. P. Naylor, 19-IX-1990.

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